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ABSTRACT

Hunting provides livelihoods and food security for a large number of people across the tropics but endangers wildlife populations. Effective management requires understanding both social and economic dynamics of local bushmeat systems, yet social elements such as relationships between actors are often overlooked. We provide the first detailed description of a rural hunting system in Liberia, from interviews with 205 hunters and 50 traders in the Gola Forest. We found bushmeat contributed substantially to local livelihoods and earnings from hunting and trading were high relative to local alternatives (median US$120 and $US262/month, hunters and traders respectively). Most of hunters' catch was sold to traders (85% of harvested biomass) and subsequently transported to urban markets (65% of all harvested biomass). Local consumption accounted for 27% of total harvest. Financial risks from meat confiscation were primarily born by traders, many of whom were women, and 60% perceived this as a motivation to reduce trading. By contrast, the most commonly stated motivation to reduce hunting was the time demanded by alternative activities such as farming. This discrepancy implies that livelihood support initiatives and law enforcement tools may play distinct roles across groups. Relationships between hunters and traders were complex and involved a variety of credit arrangements. Interpersonal trust played an important role, with mistrust of hunters being cited by 12% of traders as the principle barrier for profiting from bushmeat trade. Our findings provide context for designing conservation strategies and suggest that underlying social processes deserve closer attention in bushmeat research.

INTRODUCTION

Over-harvesting of wildlife for human consumption is a problem for wildlife populations and the humans who depend on them. Hunting provides a valuable source of income and food for a large number of people living around tropical forests (Cawthorn and Hoffman 2015) but is unsustainable at current levels (Benítez-López et al. 2017) and puts species at risk of extinction (Oates et al. 2010; Milner-Gulland et al. 2002). A good understanding of both the social and ecological elements of hunting systems is needed to develop effective tools to address this problem (Milner-Gulland 2012; Dorward 2014). Information about the contribution of bushmeat to local livelihoods, actors in the supply chain, their motivations and their interpersonal relationships provides valuable context for designing hunting reduction programmes. Closer attention to social features in this system could reveal barriers and incentives for behaviour change that are often overlooked by conservationists.

The role of bushmeat in people's livelihoods varies across sites; in many cases it provides a cheap source of protein as well as income (Foerster et al. 2012; Golden et al. 2014; Schulte-Herbrüggen et al. 2013). The commercial supply chain typically involves multiple actors: traders or intermediaries who transport meat to markets, market-sellers, restaurateurs and consumers (Cowlishaw, Mendelson, and Rowcliffe 2005; Nielsen, Meilby, and Smith-Hall 2016). Commercial hunting can be financially rewarding relative to local income alternatives (e.g. Coad et al. 2010; Nielsen and Meilby 2015), and bushmeat may provide an economic safety net (Enuoh and Bisong 2014), help to smooth income across lean seasons (Schulte-Herbrüggen et al. 2013), or generate social capital (De Merode, Homewood, and Cowlishaw 2004; van Vliet et al. 2015). The economic value of bushmeat presents a challenge of motivating behaviour change in individuals who have strong financial incentives to continue hunting, while ensuring that conservation efforts do not negatively impact vulnerable people (Roe 2008).

Conservation strategies often aim to influence economic drivers of hunting. Regulatory interventions introduce financial risks such as fines for non-compliance with hunting restrictions (Tranquilli et al. 2014), while incentive-based approaches aim to alleviate economic dependence on wildlife resources (Wright et al. 2016; Roe et al. 2015; Niesten, Zurita, and Banks 2010) or financially motivate behaviour change (Ferraro and Kiss 2002). Projects often promote environmentally sustainable income sources (Roe et al. 2014; Wicander and Coad 2015), such as bee-keeping, while tools from social development, such as micro-credit schemes, are intended to improve social outcomes of conservation projects (Kaaya and Chapman 2017). Aiming to change behaviour, cultural norms, and decision-making infrastructure, such interventions have the potential to alter social dynamics of local systems, which in turn may influence how natural resources are used (Miller, Caplow, and Leslie 2012). However, such feedback mechanisms are poorly understood (Larrosa, Carrasco, and Milner-Gulland 2016), and there is little empirical guidance for conservation managers when it comes to designing interventions.

The social context in which bushmeat hunting occurs may be central to developing effective conservation strategies. Social factors have a strong influence on behavioural decisions (Farrow, Grolleau, and Ibanez 2017; Morsello et al. 2015) and are inherent in bushmeat systems which typically involve multiple stakeholders. Yet components such as inter-personal relationships remain largely overlooked in conservation research (Robards et al. 2011). The handful of studies examining social features of bushmeat systems provide valuable insights (Cowlishaw, Mendelson, and Rowcliffe 2005; Nielsen and Meilby 2015; Vliet et al. 2014; van Vliet et al. 2015; Coad et al. 2013; Nielsen, Meilby, and Smith-Hall 2016). For instance, Neilsen *et al.* (2016) describe an illegal bushmeat trading system built upon long-term relationships between hunters, traders and consumers, in which access to a trusted network created an entry barrier for hunting. The contrasting lack of inter-personal relationships with law-enforcers in this system may have contributed to violent rent-seeking behaviour. In the Amazon

basin, van Vliet *et al* (2015) revealed substantial non-commercial flows of bushmeat to urban centres via close friendships and family ties, with sharing of meat linked to cultural identity and norms of reciprocity. Commercial trade meanwhile, was associated with a distinct socio-economic group who consumed meat as a luxury item. Framing bushmeat as a problem of common resource governance could also generate helpful insights (Smith et al. 2019) and adds prominence to factors such as trust and cooperation, which are often overlooked. Social environments can change rapidly in response to political, economic or technological shifts, which can have important consequences for resource use (Nackoney et al. 2014; Walters et al. 2015). A better understanding of the social context in which hunting systems operate provides a basis for designing appropriate conservation interventions and advances our understanding of behaviour change tools more generally.

Liberia is under-represented in the bushmeat literature (Taylor et al. 2015) despite high levels of bushmeat consumption and globally threatened wildlife populations. Anstey (1991) estimated that bushmeat provided 75% of the country's meat, generating $24 million annually. A survey conducted after the civil conflict suggested that 80% of Monrovia's population consumed bushmeat, and found evidence that Liberia supplied a global trade with international exports from the capital (CEEB, 2004). More recently, a nationwide survey confirmed that hunting and consumption remains widespread (Junker, Boesch, Mundry, et al. 2015), although consumption decreased somewhat among wealthier households during the Ebola crisis in 2014-15 (Ordaz-Németh et al. 2017). This high level of demand coincides with an area of high conservation priority: Liberia retains the largest portion of forest in the Upper Guinea biodiversity hotspot (Mittermeier et al. 2003) and consequently harbours populations which are critical to the long-term survival of species such as Western Chimpanzee (*Pan troglodytes verus)* (Kühl et al. 2017) and Pygmy Hippopotamus (*Hexaprotodon liberiensis)* (Hillers et al. 2016). Over-hunting remains one of the principle threats for wildlife in Liberia and has resulted in local extirpation of

large-bodied species (Tweh et al. 2014; Junker, Boesch, Freeman, et al. 2015). Financial incentives for hunters are likely to be high. The only existing study of hunters' incomes found average returns exceeded US$1500/month for hunters in commercial camps near Sapo National Park (Greengrass 2016). The economic role of bushmeat in rural livelihoods outside of professional hunting camps is largely undescribed and a better understanding of the economic and social structure of bushmeat systems in Liberia is needed to support conservation efforts in the region.

We aim to describe the structure of a bushmeat trading system in Liberia from a social, economic and livelihood perspective. We use a case-study from the Gola Forest to examine livelihood dependence, motivations and inter-personal relationships between hunters and traders.

METHODS

Study site

The study was conducted in Kongba District, West Liberia, at the site of the Gola Management Agreement (GolaMA) conservation project (www.golarainforest.org/gola-liberia). The area covers approximately 400km² of lowland rainforest, bordering Sierra Leone and connecting two protected areas that together form a transboundary "Peace Park", the Gola Forest National Park in Liberia, and the Gola Rainforest National Park in Sierra Leone. In Liberia, national laws prohibit hunting within protected areas and of certain species irrespective of where they are caught (Wildlife Act, 2016).

GolaMA is a community-based conservation management program that began in 2014, implemented by the Society for Conservation of Nature of Liberia and the Royal Society for the Protection of Birds. At the time of data collection, GolaMA's work focused on supporting communities to apply for legal forest

management rights and introducing small-scale livelihood support projects such as agricultural training and bee-keeping initiatives. As in much of rural West Africa, subsistence agriculture forms a major component of local livelihood strategies, along with commercial crops including oil-palm and cocoa. The study area is also notable for diamond and gold deposits, and small-scale mining is a locally significant activity. The site has relatively low population density and high quality of forest resources (Hillers, 2013). Previous work shows hunting is practiced by about 40% of households, and hunters use shotguns (39%), snares (24%) or both (37%) (Jones et al. 2019). A more detailed analysis of the demographic, livelihood and behavioural profiles of hunters in the site is presented by Jones et al (2019).

Familiarity with the study site was obtained by SJ over a period of two years, and AF and ZN are local to the region. Data were collected by researchers who were local residents and where possible, female researchers conducted interviews with traders, many of whom were women. Interviews were conducted in English or local dialects based on respondents' preference. Preliminary results of a study using specialised techniques for asking sensitive questions (Lau et al. 2011; Nuno and St. John 2014) confirmed that hunters and traders were comfortable openly discussing hunting and bushmeat trading, as well as other potentially sensitive topics such as income sources (Jones et al, unpublished). Ethical approval was given by Royal Holloway University of London Ethics Committee.

Hunters

Interviews were conducted between July 2016 – July 2017 at all villages (n=15) and two semi-permanent camps in the study site. Hunters were identified through meetings coordinated by chief hunters at each village, a household survey and snowball sampling. If hunters were not available for interview, researchers returned a minimum of three times before excluding them from the study. Hunters were asked general questions about their hunting activity and to provide details of their most recent hunting

trip including species killed, the sale or consumption of carcasses, and prices received. To determine trade routes, hunters were asked the final destination of meat sold to traders. Hunters that could be re-found were interviewed multiple times giving information for up to three separate hunting trips. Liberian dollars were converted to US$ using the local exchange rate in July 2017 (LD100:US$1). Catch was converted to raw biomass based on values in Kingdon (2015) and Jones et al (2009). Additional information relating to hunters' socio-demographic profiles were obtained during the hunter interviews and are presented in separate study (Jones et al. 2019).

The perceived contribution of hunting to personal income relative to other activities was assessed by inviting participants to share a pile of 20 beans among the income generating activities they had profited from in the past year. This was repeated for the past months' income share. Participants were also asked to estimate the income each activity generated over an average month and the previous year. Sample sizes are reported for questions about contribution of hunting to personal income that were added part way through the study.

Traders

Interviews were conducted with all traders identified in ten villages in the study site. We defined 'trader' as anyone who bought meat from one or more hunters and re-sold it. Five villages and two semi-permanent camps within the study site were not included due to their small size and inaccessibility (two camps), because no traders were identified or encountered (three villages) or due to time constraints (two villages). Traders were identified in the same way as hunters. Respondents were asked about trading behaviour and to provide details of their most recent transaction including species bought and sold. Contribution of trading to personal income was assessed with the bean-sharing method described above. Specific information regarding trade routes and customers was not requested as this

could have led to targeted law enforcement efforts at road blocks. For this reason, we do not distinguish traders who acted as intermediaries by transporting meat for resale to market sellers or restaurateurs, from end-of-chain suppliers selling directly to consumers. However, it is our understanding that sales of meat transported to urban centres were typically made to market sellers, while local sales were to consumers.

Focus group discussions

Focus group discussions were conducted to generate broader understanding of hunting and trade by capturing personal perspectives of actors (Nyumba et al. 2018). One discussion per group was conducted with hunters in six villages and traders in one village. Groups comprised six to nine participants, recruitment was opportunistic based on availability of individuals encountered by the facilitator. Hunter discussions were mediated by a facilitator and recorded with a sound recorder. The trader focus group was restricted to female participants and mediated by a female facilitator with data recorded by a female note-taker. Topics discussed were: the challenges and benefits of bushmeat hunting or trade and the role of bushmeat in relation to other livelihood activities.

RESULTS

Socio-economic aspects of the hunting system

Hunters

A total of 213 hunters were identified, of which 205 participated in the study. Of these, 48 hunters were interviewed on more than one occasion giving a sample of 253 hunting trips, totalling 999 hunting days.

Hunter catch totalled 2088 carcasses from 30 species: 27 mammals, 2 birds and 1 reptile (Supporting Information). Total harvested biomass was approximately 29 metric tonnes.

Hunters sold the majority of catch to traders (Figure 1). Sales to traders for transport to urban markets included 24 species and accounted for most of the carcasses and harvested biomass. The most common destination for meat was Liberia's capital, Monrovia, followed by markets in Sierra Leone and neighbouring Liberian counties. Hunters did not know the destination of 8% of carcasses (8% of biomass). Mean sale price reported by hunters was US$ 0.82 kg^{-1} raw weight (SD=0.37, range=0.05-2.78, n=763 transactions) and did not vary substantially by species (Supporting Information). Mean price that traders reported paying hunters was slightly lower than the price hunters reported receiving from traders (US$0.70 kg^{-1}, SD=0.18, n=114 transactions, compared to US$0.82 kg^{-1}, SD=0.39, n=636 transactions).

Hunting was the principle income source for most hunters (74%) followed by farming (19%). Hunters estimated that bushmeat provided 62% of their income during the previous month on average (range=5-100%) and 55% of income for the past year (range=5-100%; Figure 2). Self-estimated monthly earnings from hunting ranged from $10-$2800 (median=120, IQR=80-200). Hunters' average gross revenue per day during their most recent hunting trip was US$22 (SD=19, range=0-110; median=$16, IQR=8-30).

Traders

A total of 51 traders were identified and 50 participated in the study. Focus groups revealed that transient, non-resident traders operated in the area but were not identified during this study. We expect the trader sample therefore to represent only a portion of trading activity, with possible bias toward residents with a high social profile. Most (80%) of traders were women and 38% came from the same

village. The majority (80%) had emigrated from elsewhere in Liberia between one and 25 years previously (median=7, IQR=3-12). Among traders interviewed, 57% reported to sell at least some of their meat locally, 90% sold meat to Monrovia, 4% to Sierra Leone and 8% to the neighbouring Liberian county of Lofa. The majority (86%) used cars to transport dried meat, and fees paid to commercial car operators ranged from US$1.2-6.8 per carcass (mean=US$3.8, SD=1.5).

Bushmeat trading was cited as the principle livelihood by the majority (78%) of traders, followed by trading in other goods (14%) such as foodstuffs, kitchenware or clothing. Traders estimated that bushmeat provided 53% of their income during the previous month on average (range=0-100%) and 49% of income for the past year (range=20-100%; Figure 2). Self-estimated maximum monthly earnings ranged from US$15-$1600 (median=262, IQR) and minimum monthly earnings ranged from US$10-$1200 (median=120, IQR=60-158). Estimates of typical monthly profits were from US$3-$600 (median=120, IQR=59-220; n=42, Figure 2). Traders sold carcasses for an average of 1.9 times the price they paid hunters (SD=0.4; range=0.2-3.4). Mean re-sale prices reported by traders was US$1.30 kg^{-1} (SD=0.54, n=119 sales). Traders often bought multiple carcasses over a period of time which were transported and/or sold together in a single 'transaction'. Traders conducted an average of 2.7 transactions per month (SD=2.1, range=0.5-15), selling an average of 17.9 carcasses per typical transaction (SD=13.90, range=1-60). Mean expenses were US$86 per transaction (median=$60, range=$2-360). Average net profit was US$87 per transaction (median=$50, range=$1-440, SD=101.6). However, a lower profit estimate of $24 (range = $1-$243) was obtained when traders were asked to recall details of species bought and sold, rather than report their overall expenses and returns. Similarly, the mean number of carcasses recalled from the most recent transaction was substantially lower than the value reported as 'typical' (mean=8.1, SD=7.0, range=1-38).

Motivations and disincentives

Confiscation of bushmeat by authorities was perceived as a considerable financial risk among both hunters and traders and was regularly mentioned in focus group discussions. Among hunters asked (n=136), 45% had previously had meat confiscated at least once, and 25% had had their meat confiscated more than once. Median value of confiscated meat was US$380 (range = US$50 to 10000, n=62). Among traders, 71% had had their meat confiscated at least once, and 58% on more than one occasion. Median value of confiscated meat was $320 (range = US$22 to 1804, n=36).

The majority of hunters and traders reported doing less hunting or trade in the previous year than the preceding one (70% of hunters, 90% of traders; Table 1). The most common reason given by hunters was involvement in other activities such as farming, followed by enforcement of government restrictions and fewer animals. Most traders cited government restrictions, followed by reduction in animal populations (Table 1). Traders asked about factors that made meat trade challenging most frequently cited confiscation of meat at roadblocks (31 respondents, 62%; Table 2), followed by the costs of transportation (6 respondents, 12%) and issues relating to mistrust with hunters (6 respondents, 12%).

Trader focus group discussion indicated transportation costs were a key factor perceived to limit bushmeat profitability and that these were exacerbated both by poorly maintained roads and a local monopoly of commercial vehicle operators. Participants noted that transportation barriers were reduced when companies (such as logging or mining companies) were active in the area. However, high costs of transporting goods simultaneously created a motivation for increased involvement in bushmeat trade. This was because traders taking bushmeat to urban centres had the opportunity to purchase goods with cash from bushmeat sales, so bushmeat was a means of subsidising transport costs of other

goods. Profit margins for non-bushmeat goods were reportedly low and more severely impacted by transport prices, motivating traders to compensate by increasing bushmeat sales to make up the shortfall.

Hunter trader relations

Partnerships between hunters and traders were frequently mentioned during focus group discussions, and 28% of hunters had a specific "business partner". Two thirds of partnerships were with female traders, and 13% were with spouses or family members. Mean duration of partnerships was 2.7 years (SD=3.4, n=39). Typically, trading partners offered hunters financial support of some kind, to be repaid with a regular supply of meat. In 68% of such arrangements, trading partners provided gun cartridges, but exchanges also included food (42%), cash advances (11%), wire for snares (8%) or other items such as batteries (5%). The most frequent agreement was that hunters provide the equivalent of two medium-sized duiker carcasses (totalling 30-40 kg in raw weight) in exchange for a box of 25 gun cartridges (39% of agreements). Other common arrangements were that hunters provide the trader with a minimum number of carcasses per month (31% of agreements), or that hunters agree to exclusively sell their catch to the partner (8%). Agreements were similar for partnerships with male or female traders. Informal discussions indicated that relationships between hunters and traders were complex and varied. For instance, traders who own small businesses offered hunters credit for goods such as food, cigarettes and alcohol, to be repaid with meat from their next hunting trip. Reports suggested some hunters followed a predictable pattern of generating debt in the village, followed by hunting trips to repay creditors – a cycle which made it hard to generate capital to pursue alternative income sources. Traders who were not local residents were reported to travel into the study site from urban centres with goods such as clothing to exchange for meat from hunters. A popular narrative was

of hunters cheating traders who provided gun cartridges and food for hunting trips, by secretly selling meat in the forest and claiming not to have caught anything. Romantic relationships between hunters and traders of different gender were also alluded to as somewhat common. It was noted that hunters were able to help girlfriends or wives by providing them with bushmeat to sell, as well as off-cuts to eat and direct financial support. Taken together, such anecdotes implied that interpersonal relationships were important components of the hunting-trading system.

DISCUSSION

This study provides the first detailed description of the social and economic structure of a rural Liberian bushmeat system. The results reveal substantial livelihood dependence on bushmeat with high financial incentives for both hunters and traders. Bushmeat demand came from both local and urban markets with a high proportion of meat destined for Monrovia. Hunters and traders each had different motivations to reduce effort, suggesting that conservation programmes need to operate across multiple groups in order to be effective. Such programmes also need to take into account the complex social contexts within which hunting and trade operates. We found evidence that inter-personal relationships between hunters and traders, characterised by credit arrangements based on mutual trust, were influential components of the system, yet these are often overlooked.

We found bushmeat was a significant cash-generating component of local livelihoods: more than half of hunters and traders estimated that bushmeat provided at least 50% of annual income, and almost three quarters of hunters considered hunting their principle profession. This reinforces the need for livelihood support tools to be integrated into conservation strategies. Financial incentives of individuals were also considerable. Typical earnings of hunters and traders were variable but high relative to local

312 employment opportunities; a pattern that has been observed at other sites across Africa (Vega et al.
313 2013; Coad et al. 2010; Olupot and Plumptre 2009). For context, local teachers earn from $40 - $100 per
314 month and park rangers are paid up to $250 per month (M. Garbo, personal communication), whereas
315 hunters reported earning $120/month and generated $10-$20/day. Traders' incomes were slightly
316 higher, with average self-estimated monthly earnings between $120 - $260. Bushmeat incomes were an
317 order of magnitude lower than those previously recorded by Greengrass (2016) at commercial camps
318 near Liberia's Sapo National Park. This is unsurprising as our study describes a village hunting system,
319 rather than a camp of professional hunters. However, the upper range of estimates in our study
320 exceeded $1000/month, suggesting that even in a village context, a minority of hunters may have
321 considerable financial incentives. Self-reported incomes should be interpreted cautiously since they are
322 prone to error and reporting bias (Krumpal 2013, Mathiowetz et al, 2002). Nevertheless, values from
323 this study fall within the range recorded for similar settings (e.g. Coad et al. 2010; Kümpel et al. 2009; De
324 Merode, Homewood, and Cowlishaw 2004; Vega et al. 2013) and provide a benchmark to inform
325 conservation efforts.
326
327 Hunters and traders gave different reasons for reducing effort in bushmeat trade. Traders most
328 frequently cited the risk of financial losses due to checkpoint confiscations, whereas most hunters cited
329 increased involvement in activities such as farming (Table 1). Checkpoints operate across Liberia and are
330 relatively cheap to maintain. We found meat confiscation generated substantial financial risks,
331 particularly for traders, many of whom had lost assets reaching hundreds of dollars. Most traders cited
332 confiscation of meat alongside transportation costs as a major barrier to generating income from trade.
333 While confiscation risk may act as a deterrent, it was insufficient to motivate hunters or traders to
334 completely abandon their activities. A principle reason given for this was lack of alternative, equivalent,
335 income sources. In contrast to traders, hunters most frequently cited doing other activities as a reason

for reduced hunting effort. This implies that promotion of non-hunting activities which are time-demanding, but profitable, could be a successful conservation tool. As with the traders' responses, stated motivations do not constitute evidence of genuine behaviour change, and should be interpreted as factors which are perceived to influence choices. Nevertheless, the difference between hunters' and traders' responses provides useful hypotheses that could be formally tested: that traders are influenced by interventions to increase financial risks, while hunters respond best to increased demands on their time from alternative activities.

Our case-study demonstrates the need to consider the wider social context of hunting in order to obtain an accurate picture of bushmeat systems. For instance, the use of cash from bushmeat sales to boost other income sources merits further attention since this implies that simple models may not capture the true economic contribution of bushmeat. Nearly a third of hunters in this study maintained specific business partnerships with traders, and credit arrangements between the two groups were varied and complex. This underlying structure has implications for the design of interventions such as small loans schemes which are likely to influence hunter-trader relations. Trust and cooperation between actors may also be influential. Untrustworthiness of hunters was seen by traders as a significant barrier for generating profit, while a small number of hunters mentioned break-down of trading partnerships as motivation for decreasing their hunting effort. The nature of hunter-trader relationships may be revealing and could be influenced by conservation actions. For instance, Nielsen et al (2016) report a system in Tanzania in which hunters advanced credit to traders – the reverse of what was observed in our study. This difference may be linked to differences in the risk and profit experienced by hunters and traders, with the implication that hunter-trader dynamics may be sensitive to interventions such as law enforcement. Trust can promote sustainable management of resources such as bushmeat by facilitating cooperative behaviour (Bouma et al. 2017; Vollan, Prediger, and Frölich 2013). However, our results

imply that higher trust and cooperation in hunter and trader partnerships may promote over-hunting, by minimising the financial risks and uncertainty faced by both parties. More generally, one-to-one relationships could make hunting systems more resistant to interventions by creating social expectations and obligations. A clearer understanding of social dynamics in bushmeat systems, and the way these are affected by conservation actions, could improve the design of interventions.

Bushmeat hunting in Liberia has received little research attention but is a major threat for endangered species in the region (Taylor et al. 2015; Greengrass 2016). Our case-study illustrates the challenge of sustainable management of bushmeat resources in the face of large financial incentives and high livelihood dependence on wildlife. We found that motivations differed between hunters and traders, suggesting a promising direction for future work lies in determining whether livelihood support and law enforcement may be more effectively targeted. Social structures and processes such as interpersonal trust, were seen to be influential and merit closer attention in bushmeat research.

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Literature cited

Anstey, S. 1991. Wildlife Utilization in Liberia: The findings of a national survey 1989-1990. Report to WWF/FDA

Benítez-López, A., R. Alkemade, A. M. Schipper, D. J. Ingram, P. A. Verweij, J. A. J. Eikelboom, and M. A. J. Huijbregts. 2017. “The Impact of Hunting on Tropical Mammal and Bird Populations.” *Science* 356

(6334): 180–83. https://doi.org/10.1126/science.aaj1891.

Bouma, Jetske, Victoria Reyes-García, Tomas Huanca, and Susana Arrazola. 2017. “Understanding Conditions for Co-Management: A Framed Field Experiment amongst the Tsimane’, Bolivia.” *Ecological Economics* 141: 32–42. https://doi.org/10.1016/j.ecolecon.2017.05.013.

Cawthorn, Donna Mareè, and Louwrens C. Hoffman. 2015. “The Bushmeat and Food Security Nexus: A Global Account of the Contributions, Conundrums and Ethical Collisions.” *Food Research International* 76 (P4): 906–25. https://doi.org/10.1016/j.foodres.2015.03.025.

Coad, L., K. Abernethy, A. Balmford, A. Manica, L. Airey, and E. J. Milner-Gulland. 2010. “Distribution and Use of Income from Bushmeat in a Rural Village, Central Gabon.” *Conservation Biology* 24 (6): 1510–18. https://doi.org/10.1111/j.1523-1739.2010.01525.x.

Coad, L., J. Schleicher, E. J. Milner-Gulland, T. R. Marthews, M. Starkey, A. Manica, A. Balmford, W. Mbombe, T. R. Diop Bineni, and K. A. Abernethy. 2013. “Social and Ecological Change over a Decade in a Village Hunting System, Central Gabon.” *Conservation Biology* 27 (2): 270–80. https://doi.org/10.1111/cobi.12012.

Cowlishaw, Guy, Samantha Mendelson, and JMarcus Rowcliffe. 2005. “Structure and Operation of a Bushmeat Commodity Chain in Southwestern Ghana.” *Conservation Biology* 19 (1): 139–49. https://doi.org/http://dx.doi.org/10.1111/j.1523-1739.2005.00170.x.

Dorward, Andrew R. 2014. “Livelisystems: A Conceptual Framework Integrating Social, Ecosystem, Development, and Evolutionary Theory.” *Ecology and Society* 19 (2). https://doi.org/10.5751/ES-06494-190244.

Enuoh, Oliver O O, and Francis E Bisong. 2014. “Rural Livelihoods Vulnerabilities and Commercial Bushmeat Hunting Challenges in Cross River National Park , Nigeria,” 822–36. https://doi.org/10.4236/nr.2014.513071.

Farrow, Katherine, Gilles Grolleau, and Lisette Ibanez. 2017. “Social Norms and Pro-Environmental

Behavior: A Review of the Evidence." *Ecological Economics* 140: 1–13. https://doi.org/10.1016/j.ecolecon.2017.04.017.

Ferraro, Paul J., and Agnes Kiss. 2002. "Direct Payments to Conserve Biodiversity." *Science* 298 (5599): 1718–19. https://doi.org/10.1126/science.1078104.

Foerster, Steffen, David S. Wilkie, Gilda A. Morelli, Josefien Demmer, Malcolm Starkey, Paul Telfer, Matthew Steil, and Arthur Lewbel. 2012. "Correlates of Bushmeat Hunting among Remote Rural Households in Gabon, Central Africa." *Conservation Biology* 26 (2): 335–44. https://doi.org/10.1111/j.1523-1739.2011.01802.x.

Golden, Christopher D., Matthew H. Bonds, Justin S. Brashares, Rodolph B. J. Rasolofoniaina, and Claire Kremen. 2014. "Economic Valuation of Subsistence Harvest of Wildlife in Madagascar." *Conservation Biology* 28 (1): 234–43. https://doi.org/10.1111/cobi.12174.

Greengrass, Elizabeth. 2016. "Commercial Hunting to Supply Urban Markets Threatens Mammalian Biodiversity in Sapo National Park, Liberia." *Oryx* 50 (03): 397–404. https://doi.org/10.1017/S0030605315000095.

Hillers, Annika, Graeme M. Buchanan, Jerry C. Garteh, Solomon M. Tommy, Mohamed L. Fofana, and Jeremy a. Lindsell. 2016. "A Mix of Community-Based Conservation and Protected Forests Is Needed for the Survival of the Endangered Pygmy Hippopotamus Choeropsis Liberiensis." *Oryx*, 1–10. https://doi.org/10.1017/S003060531600020X.

Jones, Sorrel, Aidan Keane, Freya St John, Juliet Vickery, and Sarah Papworth. 2019. "Audience Segmentation to Improve Targeting of Conservation Interventions for Hunters." *Conservation Biology* 0 (0): 1–11. https://doi.org/10.1111/cobi.13275.

Junker, Jessica, Christophe Boesch, Theo Freeman, Roger Mundry, Colleen Stephens, and Hjalmar S. Kühl. 2015. "Integrating Wildlife Conservation with Conflicting Economic Land-Use Goals in a West African Biodiversity Hotspot." *Basic and Applied Ecology* 16 (8): 690–702.

https://doi.org/10.1016/j.baae.2015.07.002.

Junker, Jessica, Christophe Boesch, Roger Mundry, Colleen Stephens, Menladi Lormie, Clement Tweh, and Hjalmar S. Kühl. 2015. “Education and Access to Fish but Not Economic Development Predict Chimpanzee and Mammal Occurrence in West Africa.” *Biological Conservation* 182: 27–35. https://doi.org/10.1016/j.biocon.2014.11.034.

Kaaya, Emmanuel, and Margaret Chapman. 2017. “Micro-Credit and Community Wildlife Management: Complementary Strategies to Improve Conservation Outcomes in Serengeti National Park, Tanzania.” *Environmental Management* 60 (3): 464–75. https://doi.org/10.1007/s00267-017-0856-x.

Krumpal, Ivar. 2013. “Determinants of Social Desirability Bias in Sensitive Surveys: A Literature Review.” *Quality and Quantity* 47 (4): 2025–47. https://doi.org/10.1007/s11135-011-9640-9.

Kühl, H.S., T. Sop, E.A. Williamson, R. Mundry, D. Brugière, G. Campbell, H. Cohen, et al. 2017. “The Critically Endangered Western Chimpanzee Declines by 80%.” *American Journal of Primatology* 79 (9). https://doi.org/10.1002/ajp.22681.

Kümpel, N. F., J. M. Rowcliffe, G. Cowlishaw, and E. J. Milner-Gulland. 2009. “Trapper Profiles and Strategies: Insights into Sustainability from Hunter Behaviour.” *Animal Conservation* 12 (6): 531–39. https://doi.org/10.1111/j.1469-1795.2009.00279.x.

Larrosa, Cecilia, Luis R. Carrasco, and E. J. Milner-Gulland. 2016. “Unintended Feedbacks: Challenges and Opportunities for Improving Conservation Effectiveness.” *Conservation Letters* 9 (5): 316–26. https://doi.org/10.1111/conl.12240.

Lau, Joseph T. F., Nelson C. Y. Yeung, Lancelot W. H. Mui, Hi Yi Tsui, and Jing Gu. 2011. “A Simple New Method to Triangulate Self-Reported Risk Behavior Data—The Bean Method.” *Sexually Transmitted Diseases* 38 (9): 788–92. https://doi.org/10.1097/OLQ.0b013e318218cc66.

Merode, Emmanuel De, Katherine Homewood, and Guy Cowlishaw. 2004. “The Value of Bushmeat and

456 Other Wild Foods to Rural Households Living in Extreme Poverty in Democratic Republic of Congo."
457 *Biological Conservation* 118 (5): 573–81. https://doi.org/10.1016/j.biocon.2003.10.005.
458 Miller, Brian W, Susan C Caplow, and Paul W Leslie. 2012. "Feedbacks between Conservation and Social-
459 Ecological Systems." *Conservation Biology* 26 (2): 218–27. https://doi.org/10.1111/j.1523-
460 1739.2012.01823.x.
461 Milner-Gulland, E. J. 2012. "Interactions between Human Behaviour and Ecological Systems."
462 *Philosophical Transactions of the Royal Society B: Biological Sciences* 367 (1586): 270–78.
463 https://doi.org/10.1098/rstb.2011.0175.
464 Milner-Gulland, E. J., Mohamed Bakarr, Heather Eves, John Robinson, and David Wilkie. 2002. "Hunting
465 the World's Wildlife to Extinction." *Oryx* 36 (October): 328–29.
466 https://doi.org/10.1017/S0030605302000637.
467 Mittermeier, R. A., C. G. Mittermeier, T. M. Brooks, J. D. Pilgrim, W. R. Konstant, G. A. B. da Fonseca, and
468 C. Kormos. 2003. "Wilderness and Biodiversity Conservation." *Proceedings of the National*
469 *Academy of Sciences* 100 (18): 10309–13. https://doi.org/10.1073/pnas.1732458100.
470 Morsello, Carla, Blanca Yagüe, Letícia Beltreschi, Nathalie van Vliet, Cristina Adams, Tatiana Schor, Maria
471 Paula Quiceno-Mesa, and Daniel Cruz. 2015. "Cultural Attitudes Are Stronger Predictors of
472 Bushmeat Consumption and Preference than Economic Factors among Urban Amazonians from
473 Brazil and Colombia." *Ecology and Society* 20 (4). https://doi.org/10.5751/ES-07771-200421.
474 Nackoney, Janet, Giuseppe Molinario, Peter Potapov, Svetlana Turubanova, Matthew C. Hansen, and
475 Takeshi Furuichi. 2014. "Impacts of Civil Conflict on Primary Forest Habitat in Northern Democratic
476 Republic of the Congo, 1990-2010." *Biological Conservation* 170: 321–28.
477 https://doi.org/10.1016/j.biocon.2013.12.033.
478 Nielsen, Martin Reinhardt, and Henrik Meilby. 2015. "Hunting and Trading Bushmeat in the Kilombero
479 Valley, Tanzania: Motivations, Cost-Benefit Ratios and Meat Prices." *Environmental Conservation*

42 (1): 61–72. https://doi.org/10.1017/S0376892914000198.

Nielsen, Martin Reinhardt, Henrik Meilby, and Carsten Smith-Hall. 2016. “How Could the Bushmeat Trade in the Kilombero Valley of Tanzania Be Regulated? Insights from the Rural Value Chain.” *Oryx* 50 (1): 84–93. https://doi.org/10.1017/S003060531400009X.

Niesten, Eduard, Patricia Zurita, and Sarah Banks. 2010. “Conservation Agreements as a Tool to Generate Direct Incentives for Biodiversity Conservation.” *Biodiversity* 11 (1–2): 5–8. https://doi.org/10.1080/14888386.2010.9712639.

Nuno, Ana, and Freya A V St John. 2014. “How to Ask Sensitive Questions in Conservation: A Review of Specialized Questioning Techniques.” *Biological Conservation* 189: 5–15. https://doi.org/10.1016/j.biocon.2014.09.047.

Nyumba, Tobias O., Kerrie Wilson, Christina J. Derrick, and Nibedita Mukherjee. 2018. “The Use of Focus Group Discussion Methodology: Insights from Two Decades of Application in Conservation.” *Methods in Ecology and Evolution* 9 (1): 20–32. https://doi.org/10.1111/2041-210X.12860.

Oates, John F, Michael Abedi-lartey, W Scott Mcgraw, Thomas T Struhsaker, George H Whitesides, T Struhsaker, and H Whitesides. 2010. “Extinction of a West African Red Colobus Monkey Extinction of a West Afican Red Colobus Monkey.” *Conservation Biology* 14 (5): 1526–32.

Olupot, William, and Andrew J Plumptre. 2009. “An Analysis of Socioeconomics of Bushmeat Hunting at Major Hunting Sites in Uganda.” *Working Paper No. 38*, no. October 2009: 108.

Ordaz-Németh, Isabel, Mimi Arandjelovic, Lukas Boesch, Tsegaye Gatiso, Trokon Grimes, Hjalmar S. Kuehl, Menladi Lormie, Colleen Stephens, Clement Tweh, and Jessica Junker. 2017. “The Socio-Economic Drivers of Bushmeat Consumption during the West African Ebola Crisis.” *PLoS Neglected Tropical Diseases* 11 (3). https://doi.org/10.1371/journal.pntd.0005450.

Robards, Martin D., Michael L. Schoon, Chanda L. Meek, and Nathan L. Engle. 2011. “The Importance of Social Drivers in the Resilient Provision of Ecosystem Services.” *Global Environmental Change* 21

(2): 522–29. https://doi.org/10.1016/j.gloenvcha.2010.12.004.

Roe, Dilys. 2008. “Trading Nature (PDF, 3 MB),” 1–100. http://www.traffic.org/general-reports/traffic_pub_gen19.pdf%5Cnpapers2://publication/uuid/90356BDA-E908-4E16-B6CB-FA7CD3A64E73.

Roe, Dilys, Francesca Booker, Mike Day, Wen Zhou, Sophie Allebone-Webb, Nicholas A. O. Hill, Noelle Kumpel, et al. 2015. “Are Alternative Livelihood Projects Effective at Reducing Local Threats to Specified Elements of Biodiversity and/or Improving or Maintaining the Conservation Status of Those Elements?” *Environmental Evidence* 4 (1): 22. https://doi.org/10.1186/s13750-015-0048-1.

Roe, Dilys, Mike Day, Francesca Booker, Wen Zhou, Sophie Allebone-Webb, Noëlle Kümpel, Nicholas a. O. Hill, et al. 2014. “Are Alternative Livelihood Projects Effective at Reducing Local Threats to Specified Elements of Biodiversity and/or Improving or Maintaining the Conservation Status of Those Elements?: A Systematic Review Protocol.” *Environmental Evidence* 3: 6. https://doi.org/10.1186/2047-2382-3-6.

Schulte-Herbrüggen, Björn, Guy Cowlishaw, Katherine Homewood, and J. Marcus Rowcliffe. 2013. “The Importance of Bushmeat in the Livelihoods of West African Cash-Crop Farmers Living in a Faunally-Depleted Landscape.” *PLoS ONE* 8 (8): 1–13. https://doi.org/10.1371/journal.pone.0072807.

Smith, Hillary, Sergio Marrocoli, Alejandro Garcia Lozano, and Xavier Basurto. 2019. “Hunting for Common Ground between Wildlife Governance and Commons Scholarship.” *Conservation Biology* 33 (1): 9–21. https://doi.org/10.1111/cobi.13200.

Taylor, G., J. P W Scharlemann, M. Rowcliffe, N. Kümpel, M. B J Harfoot, J. E. Fa, R. Melisch, et al. 2015. “Synthesising Bushmeat Research Effort in West and Central Africa: A New Regional Database.” *Biological Conservation* 181: 199–205. https://doi.org/10.1016/j.biocon.2014.11.001.

Tranquilli, Sandra, Michael Abedi-Lartey, Katharine Abernethy, Fidèle Amsini, Augustus Asamoah, Cletus Balangtaa, Stephen Blake, et al. 2014. “Protected Areas in Tropical Africa: Assessing Threats and

528 Conservation Activities." *PLoS ONE* 9 (12): 1–21. https://doi.org/10.1371/journal.pone.0114154.
529 Tweh, Clement G., Menladi M. Lormie, Célestin Y. Kouakou, Annika Hillers, Hjalmar S. Kühl, and Jessica
530 Junker. 2014. "Conservation Status of Chimpanzees *Pan Troglodytes* Verus and Other Large
531 Mammals in Liberia: A Nationwide Survey." *Oryx* 49 (04): 710–18.
532 https://doi.org/10.1017/S0030605313001191.
533 Vega, María Grande, Bruno Carpinetti, Jesús Duarte, and John E. Fa. 2013. "Contrasts in Livelihoods and
534 Protein Intake between Commercial and Subsistence Bushmeat Hunters in Two Villages on Bioko
535 Island, Equatorial Guinea." *Conservation Biology* 27 (3): 576–87.
536 https://doi.org/10.1111/cobi.12067.
537 Vliet, Nathalie Van, Maria Paula Quiceno-mesa, Daniel Cruz-antia, Lindon Jonhson, Neves De Aquino,
538 Jessica Moreno, and Robert Nasi. 2014. "The Uncovered Volumes of Bushmeat Commercialized in
539 the Amazonian Trifrontier between Colombia, Peru & Brazil." *Ethnobiology and Conservation* 7
540 (November): 1–11. https://doi.org/10.15451/ec2014-11-3.7-1-11.
541 Vliet, Nathalie van, Maria Paula Quiceno, Daniel Cruz, Lindon Jonhson Neves de Aquino, Blanca Yagüe,
542 Tatiana Schor, Sara Hernandez, and Robert Nasi. 2015. "Bushmeat Networks Link the Forest to
543 Urban Areas in the Trifrontier Region between Brazil, Colombia, and Peru." *Ecology and Society* 20
544 (3): art21. https://doi.org/10.5751/ES-07782-200321.
545 Vollan, Björn, Sebastian Prediger, and Markus Frölich. 2013. "Co-Managing Common-Pool Resources: Do
546 Formal Rules Have to Be Adapted to Traditional Ecological Norms?" *Ecological Economics* 95: 51–
547 62. https://doi.org/10.1016/j.ecolecon.2013.08.010.
548 Walters, Gretchen, Judith Schleicher, Olivier Hymas, and Lauren Coad. 2015. "Evolving Hunting Practices
549 in Gabon: Lessons for Community-Based Conservation Interventions." *Ecology and Society* 20 (4).
550 https://doi.org/10.5751/ES-08047-200431.
551 Wicander, Sylvia, and Lauren Coad. 2015. "Learning Our Lessons Eci Learning Our Lessons." Oxford.

https://doi.org/10.2305/IUCN.CH.2015.01.en.

Wright, Juliet H., Nicholas A O Hill, Dilys Roe, J. Marcus Rowcliffe, Noëlle F. Kümpel, Mike Day, Francesca Booker, and E. J. Milner-Gulland. 2016. “Reframing the Concept of Alternative Livelihoods.” *Conservation Biology* 30 (1): 7–13. https://doi.org/10.1111/cobi.12607.

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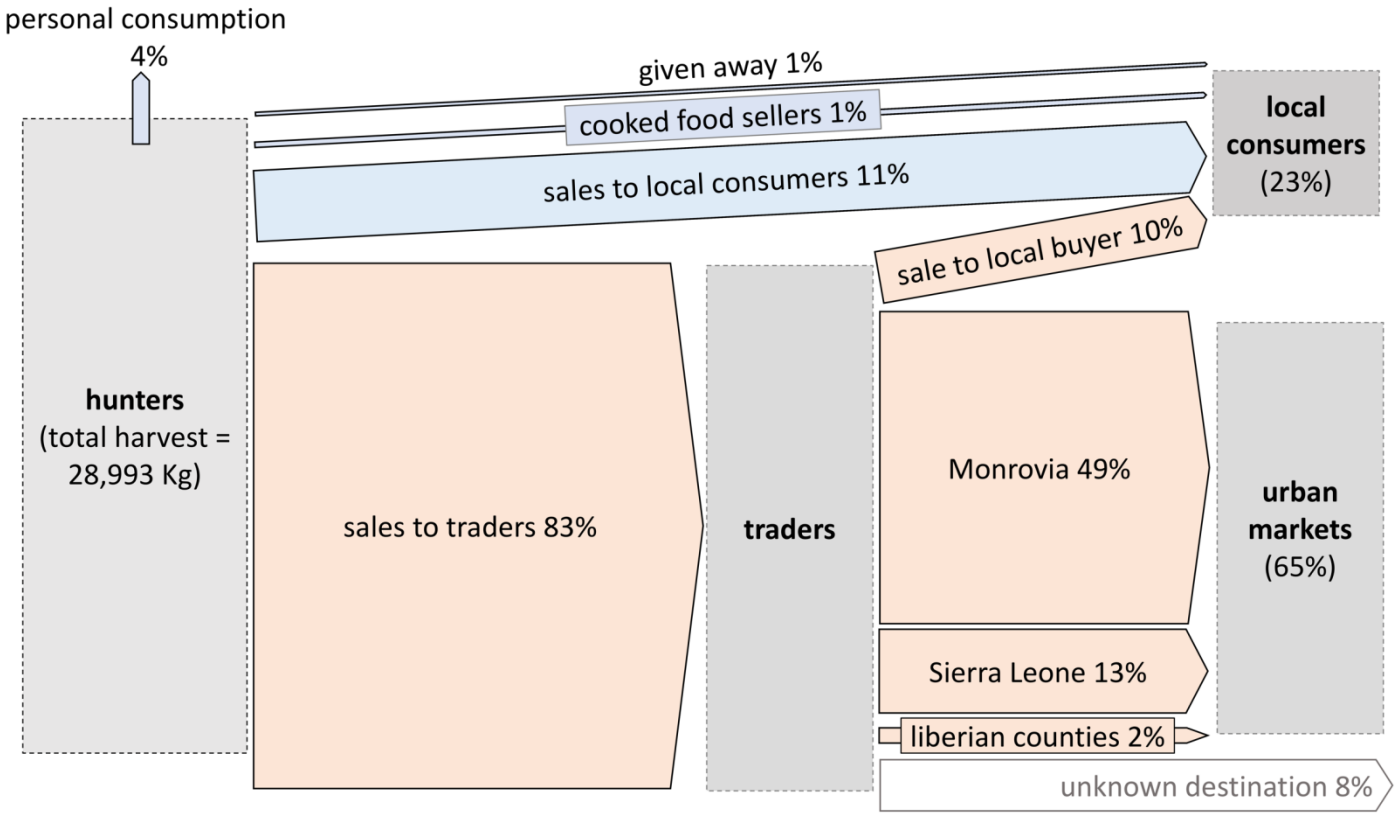

560 Figure 1. Destination of wildlife harvest based on hunters' reports (n=253 hunting trips). All values

561 shown are percentages of original total harvested biomass and width of arrows is proportional to

562 volume in Kg.

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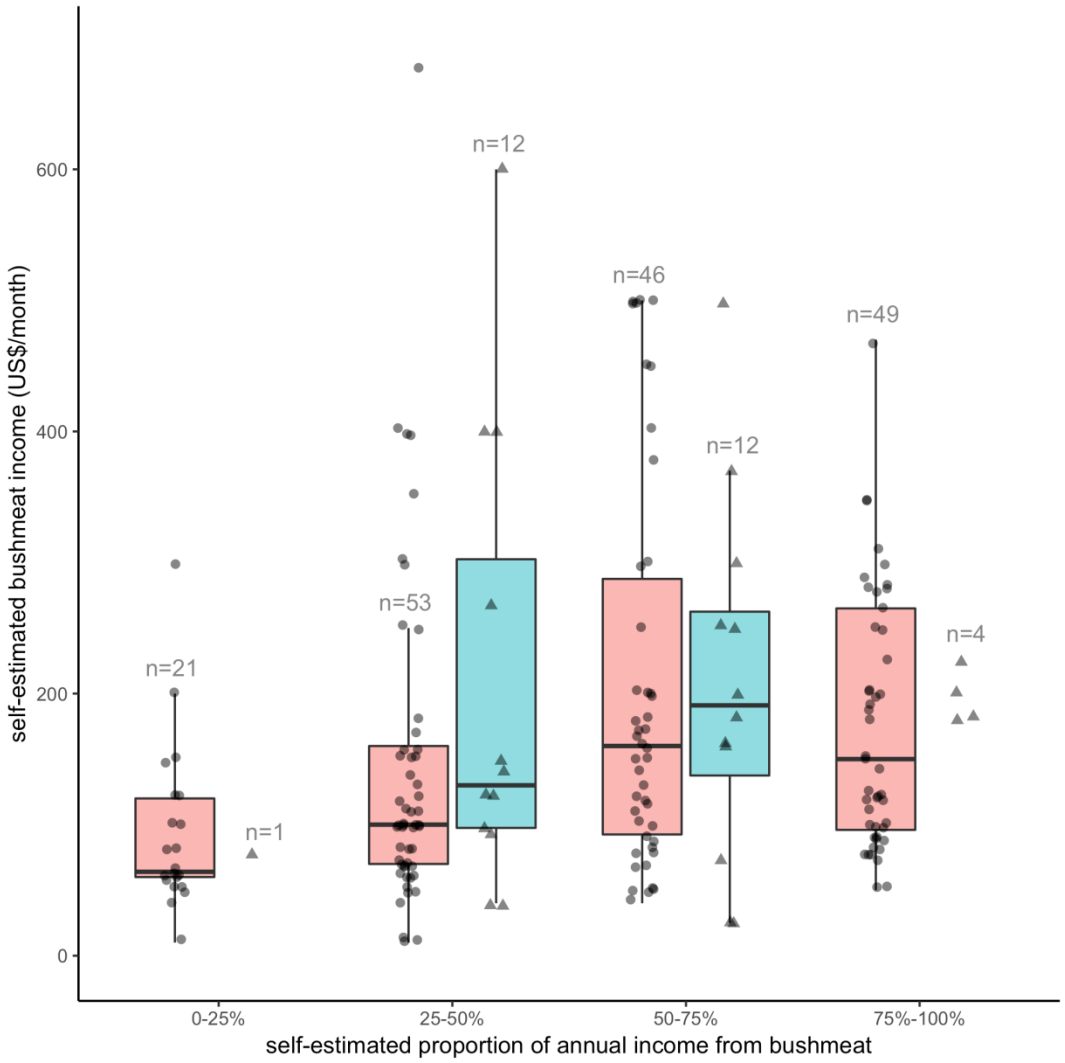

Figure 2. Bushmeat income estimated by hunters (red, circles, n=169) and traders (blue, triangles, n=29), grouped according to perceived proportion of annual income from bushmeat. Four high hunter estimates are omitted for clarity, from income proportion categories 25-50% ($800/month), 50-75% ($800 and $900/month) and 75-100% ($2800/month). Boxes indicate median and 25% - 75% quartile range for cases with at least 10 values, whiskers extend to 1.5xIQR beyond boxes.

572 Table 1. Reasons given by hunters (n=92) and traders (n=45) who stated during interviews they had
573 reduced their effort in bushmeat activities in the previous year compared to the preceding one. Values
574 are the percentage and number of total respondents giving each reason.

Reasons for reduction in hunting / trading effort in the previous year (*example statements*)	Hunters	Traders
Government restrictions and law enforcement *"the arresting of meat on the road"* *"because they're taking the meat from us"*	21% (19)	60% (27)
Replacement with a different income generating activity *"farming is now my focus point"* *"because I went to gold mining"* *"busy with farming"* *"I have more activities this year than hunting"*	32% (29)	(0)
Fewer animals *"the animals are not as many compared to last year"* *"I travel far distance in hunting and get less animals"*	21% (19)	16% (8)
Awareness about conservation, GolaMA project activities *"conservation message"* *"golama say no hunting"*	13% (12)	7% (3)
Personal / health issues	8% (7)	4% (2)
Financial barriers, lack of gun *"bullets are expensive"* *"someone go with my gun"*	5% (5)	2% (1)
Limited by supply from hunters, or support from traders *"more hunters leaving their hunting tent"* *"because the hunters are not doing any hunting"* *"I did more hunting[before] because of my partner help"*	1% (1)	4% (2)
Transportation issues *"poor road condition"*	(0)	2% (1)

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577 Table 2. Factors considered by traders to be the principle challenges of bushmeat trading, data from

578 interviews with 50 traders.

Principle challenges for bushmeat traders (*example statements*)	Percentage of respondents
Government restrictions and law enforcement *"FDA[Forestry Development Authority of Liberia] law"* *"the arresting of meat on the road"*	62% (31)
Trustworthiness of hunters *"you paid the hunters for the meat and you don't get it sometime"* *"some hunters will carry your money and don't come back"* *"we have to go after some of the hunter to get [our] goods"* *"to get dry meat from the hunter is not easy"*	12% (6)
Poor road condition *"bad road condition and huge transportation fare"* *"accessibility, poor road conditions"*	12% (6)
Travelling long distances *"moving from one place to another to get meat"* *"walking from place to another"* *"going on far distance to get the meat, sometime you don't see the hunter"*	8% (4)
Conservation *"Due to conservation"*	4% (2)
Declining wildlife abundance *"shortage of animals"*	2% (1)
Other – personal	2% (1)

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Appendix A.

Table A1. Species harvested by 208 hunters over 999 hunting days in the Gola Forest, based on recall from most recent hunting trip. Ordered by percentage of total biomass.

Species	Species group	number of carcasses	total biomass (Kg)	percent of all carcasses	percent of total biomass	destination of carcasses
Cephalophus dorsalis	medium ungulate	500	10000.0	23.1	27.7	urban + local
Philantomba maxwellii	small ungulate	811	6940.3	37.4	19.2	urban + local
Syncerus caffer nanus	large ungulate	11	6519.3	0.5	18.0	urban + local
Potamochoerus porcus	large ungulate	49	3430.0	2.3	9.5	urban + local
Cephalophus niger	medium ungulate	117	2234.0	5.4	6.2	urban + local
Hylochoerus meinertzhageni	large ungulate	4	792.5	0.2	2.2	urban + local
Cercocebus atys	primate	114	791.3	5.3	2.2	urban + local
Tragelaphus scriptus	medium ungulate	17	735.3	0.8	2.0	urban + local
Cephalophus jentinki	large ungulate	9	616.4	0.4	1.7	urban
Tragelaphus eurycerus	large ungulate	2	542.0	0.1	1.5	urban
Colobus polykomos	primate	59	519.0	2.7	1.4	urban + local
Hyemoschus aquaticus	medium ungulate	46	499.1	2.1	1.4	urban + local
Choeropsis liberiensis	large ungulate	2	470.0	0.1	1.3	urban
Atherurus africanus	rodent	108	310.6	5.0	0.9	urban + local
Monkey - undefined species	primate	51	296.6*	2.4	0.8	urban + local
Cercopithecus diana	primate	59	257.2	2.7	0.7	urban + local
Cercopithecus petaurista	primate	70	226.4	3.2	0.6	urban + local
Pan troglodytes verus	primate	5	225.0	0.2	0.6	urban
Piliocolobus badius	primate	25	210.8	1.2	0.6	urban + local
Thryonomys swinderianus	rodent	33	123.8	1.5	0.3	local
Cercopithecus campbelli	primate	32	116.1	1.5	0.3	urban + local
Panthera pardus	carnivore	2	104.8	0.1	0.3	urban
Cephalophus silvicultor	large ungulate	1	62.0	0.0	0.2	urban
Cephalophus ogilbyi ssp brookei	medium ungulate	2	36.8	0.1	0.1	urban
Crocodile[1]	reptile	1	25.0*	0.0	0.1	local
Nandinia binotata	carnivore	9	19.5	0.4	0.1	urban + local
Mongoose - undefined species	carnivore	11	15.3*	0.5	<0.1	local
Agelastes meleagrides	bird	16	13.0	0.7	<0.1	local
Large raptor or Palm-nut vulture	bird	2	7.2*	0.1	<0.1	local
Manis tricuspis	pangolin	1	1.5	<0.1	<0.1	local

* For undefined species, body mass of the most commonly killed member of the species group were used based on information provided by hunters. For monkeys the mean adult body mass of all monkey species was used.

[1]*Osteolaemus tetraspis* or *Mecistops cataphractus*

Appendix B

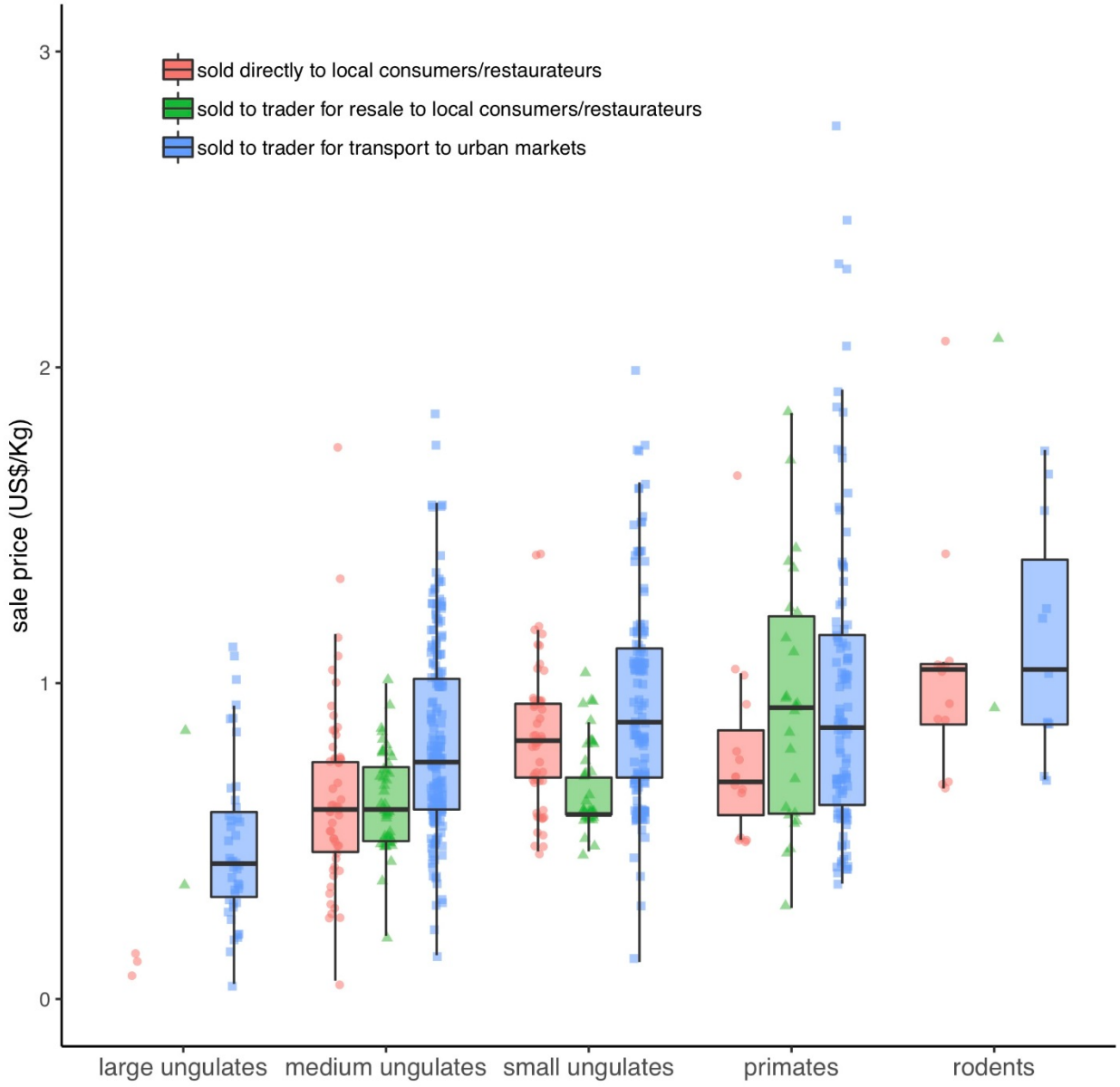

Figure B.1. Prices received by hunters from bushmeat sold directly to local consumers or restaurateurs (red, circles), to traders intending to sell the meat to local consumers or restaurateurs (green, triangles), and to traders for transport to urban centres (blue, squares). Points show values of individual transactions (n=759). Boxes indicate median and 25% - 75% quartile range for cases with at least ten transactions, whiskers extend to 1.5xIQR beyond boxes.

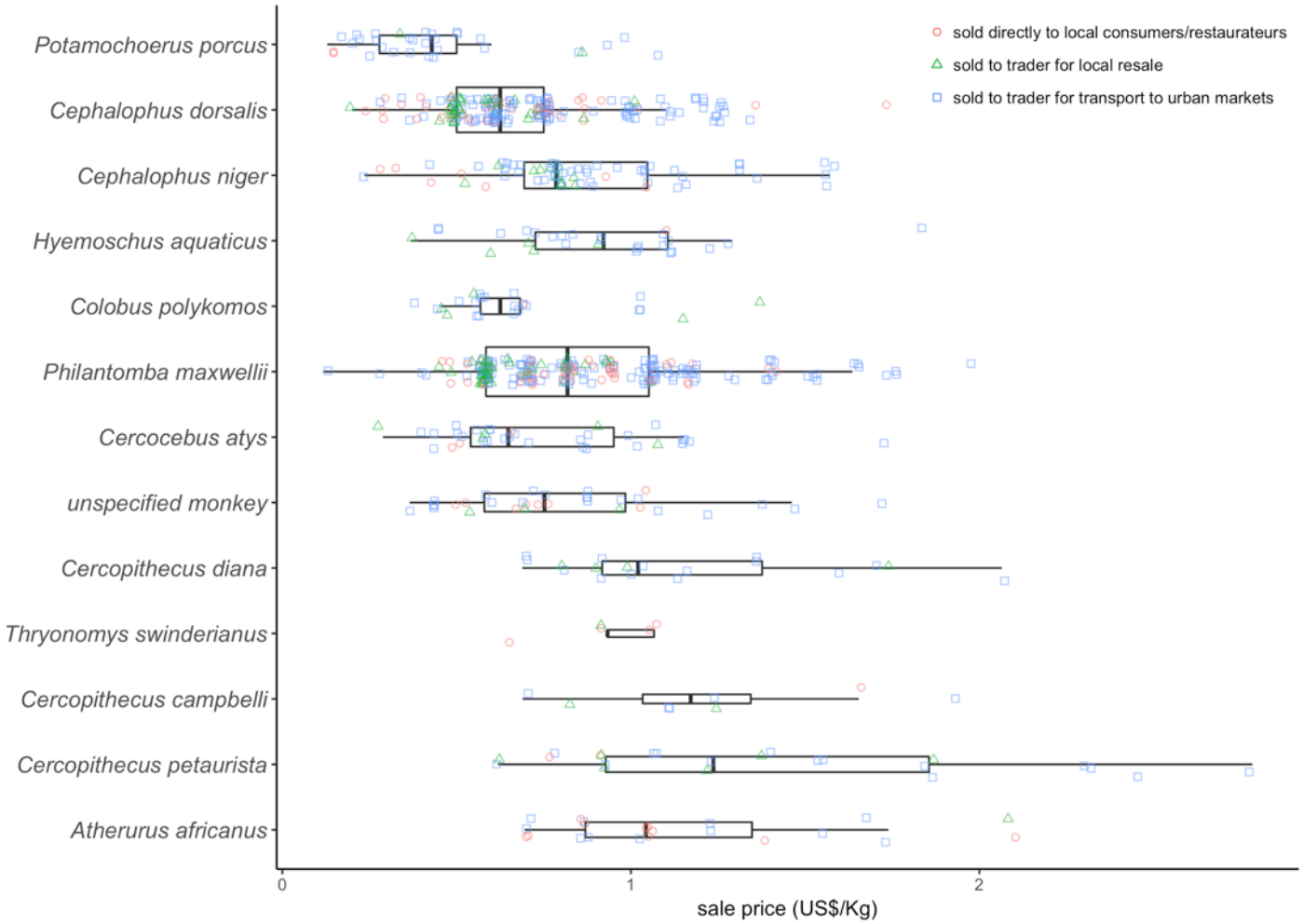

Figure B.2. Sale prices received by hunters for the most frequently killed species, in order of body size. Points indicate hunters' sales directly to local consumers or restaurateurs (red circles), sales to traders for local resale (green triangles), or sales to traders for transport to urban markets (blue squares). Median and 25% - 75% quartiles range are indicated by boxes, widths are proportional to the number of carcasses sold. Species are ordered by mean body size (smallest at the bottom).

Appendix C

Table C.1. Factors considered by traders to be the principle challenges of bushmeat trading, data from interviews with 50 traders.

Principle challenges for bushmeat traders (*example statements*)	Percentage of respondents
Government restrictions and law enforcement "*FDA [Forestry Development Authority of Liberia] law*" "*the arresting of meat on the road*"	62% (31)
Trustworthiness of hunters "*you paid the hunters for the meat and you don't get it sometime*" "*some hunters will carry your money and don't come back*" "*we have to go after some of the hunter to get [our] goods*" "*to get dry meat from the hunter is not easy*"	12% (6)
Poor road condition "*bad road condition and huge transportation fare*" "*accessibility, poor road conditions*"	12% (6)
Travelling long distances "*moving from one place to another to get meat*" "*walking from place to another*" "*going on far distance to get the meat, sometime you don't see the hunter*"	8% (4)
Conservation "*Due to conservation*"	4% (2)
Declining wildlife abundance "*shortage of animals*"	2% (1)
Other – personal	2% (1)